SAMPLE MASKING TO REDUCE SUBSTRATE BACKSIDE REFLECTIONS

This Application Claims Benefit of Provisional Application Serial No. 60/452,673 Filed 03/10/2003.

TECHNICAL AREA

The disclosed invention relates to the use of electromagnetic radiation to investigate samples, and more particularly to the placing of an electromagnetic radiation absorbing and/or scattering and/or reflecting, (in a direction not parallel to electromagnetic radiation reflected from the sample surface), mask directly atop a sample, which mask allows electromagnetic radiation to access the sample over only a limited area determined by angle of incidence, sample thickness, and ambient and substrate refractive indicies.

BACKGROUND

It is known to impinge electromagnetic radiation onto a sample at an oblique angle, and collect electromagnetic radiation which reflects from the sample, then via detected change in the polarization state determine properties of the sample. A problem which occurs, however, where a sample is not effectively infinitely thick, is that the reflected electromagnetic radiation includes components which reflect not only from the actual sample surface, and perhaps interfaces between thin films thereupon, but also from the back side of the substrate. Said reflection from the substrate backside confuses interpretation of the results, and while such can be accounted for in a mathematical model of the sample, it is often preferable to block said backside reflections and avoid the confusing effects thereof.

One approach to preventing backside reflections is to physically roughen the backside, however this approach alters the sample. The invention disclosed herein provides a simple approach to avoiding the effect of backside reflections without requiring sample modification.

With the present invention in mind a Search was conducted for Patents that disclose means for blocking backside reflections from entering a detector. Patent Application No. 2002/0113200 A1 was identified as an aperture 103A is disclosed which can be placed near a detector to block entry of one of two beams from different sources. Patent No. 3,799,679 to Simko is disclosed as an iris (38) is present near a detector which can be adjusted to block entry of backside reflection thereinto. Patents to Meeks, Nos. 6,130,749, 6,198,533 and 6,392,749 are disclosed for the presence of a hole 2022 in an integrating sphere near, but not atop a sample. Patent No. 6,088,092 to Chen et al. is disclosed as it applies a spatial filter (28) to block backside reflection entry into a detector. Patent No. 6,088,104 to Peterson is disclosed as a blocking element (B) is present which can be used to block electromagnetic radiation entry to a detector. Patent No. 6,097,482 to Smith et al. is disclosed as it applies baffles to block light entry to a detector. Patent No. 6,166,808 to Greve is disclosed as it describes use of an aperture near a detector to block backside reflections entry to a detector.

Even in view of the known prior art, need remains for a simple to practice method for avoiding effects of sample backside reflections which does not require sample, or investigating system alteration.

DISCLOSURE OF THE INVENTION

The disclosed invention is a method of investigating a sample which comprises at least one thin film (TF) on the surface of a substrate (SUB) with a beam of electromagnetic radiation (EMI) which impinges thereupon at an oblique angle of incidence (Θ). Said method eliminates the effects of reflection from the backside (BS) of said substrate (SUB) in a beam of electromagnetic radiation (EMR) which reflects from the surface (SUR) of the at least one thin film (TF), and comprises the steps of:

providing a substrate (SUB) with at least one thin film (TF) on the surface thereof, said at least one thin film (TF) presenting a surface (SUR);

causing an incident beam of electromagnetic radiation (EMI) of cross sectional diameter (BW) to impinge upon the sample thin film surface (SUR) at an oblique angle of incidence (Θ), and

simultaneously placing a mask (M) which is made from an electromagnetic beam:

absorbing, and/or
scattering, and/or
relecting of electromagnetic radiation in a direction not parallel to electromagnetic radiation reflected from the substrate surface,

material upon the surface (SUR) of the at least one thin film (TF), said mask having a hole (H) therein with an effective radius (D) which is related to the thickness (T) of the sample by the equation:

$$D <= 2T \tan(\Theta')$$;

where (T) is the combined thickness of said at least one thin film (TF) and the substrate (SUB).

In use said incident electromagnetic beam (EMI) reflects from the surface (SUR) of said at least one thin film (TF) as reflected electromagnetic beam (EMR), said reflected electromagnetic beam (EMR) having no component therein which reflected from the backside (BS) of said substrate (SUB). The method continues by causing said reflected beam of electromagnetic radiation (EMR) to be analyzed.

The disclosed method of investigating a sample with a beam of electromagnetic radiation (EMI) which impinges thereupon at an oblique angle of incidence (Θ) can also be applied to a substrate (SUB) which has no significant thin film(s) present on its surface, again to eliminate the effects of reflection from the backside (BS) of said substrate (SUB) in a beam of electromagnetic radiation (EMR) which reflects from the surface (SUR) of said substrate. The method then comprises:

providing a substrate (SUB) presenting a surface (SUR);

causing an incident beam of electromagnetic radiation (EMI) of cross sectional diameter (BW) to impinge upon the substrate surface (SUR) at an oblique angle of incidence (Θ), and

simultaneously placing a mask (M) which is made from an electromagnetic beam absorbing and/or scattering and/or reflecting, (of electromagnetic radiation in a direction not parallel to electromagnetic radiation reflected from the substrate surface), material upon the surface (SUR) of said substrate, said mask having a hole (H) therein with an effective radius (D) which is related to the thickness (T) of the substrate by the equation:

$$D <= 2T \tan(\theta');$$

where (T) is the thickness of said substrate (SUB).

As in the above example, said incident electromagnetic beam (EMI) reflects from the surface (SUR) of said substrate as reflected electromagnetic beam (EMR), which reflected electromagnetic beam (EMR) has no component therein which was reflected from the backside (BS) of said substrate (SUB), and again, the method continues by causing said reflected beam of electromagnetic radiation (EMR) to be analyzed.

The invention will be better understood by reference to the Detailed Description Section of the Specification, in conjunction with the Drawings.

SUMMARY

It is therefore a primary purpose and/or objective of the disclosed invention to teach a simple system, and method of its application to block reflections from the backside of a sample from reaching a detector, which reflections result from a beam of electromagnetic radiation impinging upon said sample surface at an oblique angle.

Additional purposes and/or objectives of the disclosed invention will become apparent from a reading of the Specification and Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 demonstrates a system containing a sample for practicing the disclosed invention.

Fig. 2 shows the relationship between the thickness (T) of the sample and the diameter (D) of the hole in the mask (M) necessary to block reflections from the backside (BS) of the substrate (SUB).

DETAILED DISCLOSURE

Turning now to Fig. 1, there is demonstrated a solution to blocking electromagnetic radiation reflection (EMR) from the backside (BS) of a sample comprising a substrate (SUB), is to place a mask (M) atop thereof. Fig. 1 realistically indicates the presence of a thin film(s) (TF) on the surface (SUR) of the substrate, (which sample comprises (SUB) + (TF)), which mask (M) is made of a material which scatters electromagnetic radiation which is impinged thereupon. Note that the mask (M) has a hole (H) therein through which electromagnetic radiation (EMI) can access the sample. If the hole (H) is of an effective diameter which is smaller than some value based upon the total thickness (T) of the thin film (TM) + the substrate (SUB), then all backside (BS) originated reflections are blocked in the reflected beam (EMR). This is the case whether the electromagnetic radiation is a beam (EMI) has an effective diameter larger or smaller than the effective hole (H) diameter.

Fig. 2 shows the relationship between the thickness (T) of the sample and the diameter (D) of the hole in the mask (M) necessary to block reflections from the backside (BS) of the substrate (SUB). Also indicated are indicies of refraction, (n0), (n1) and (n2) for the ambient, thin film (TF) and substrate (SUB) respectively. Formulas which relate the thin film (TF) thickness (T) to the effective diameter of the hole (H) are also shown in Fig. 2 as:

$$D \le 2T \, \mathrm{TAN}\,(\theta'); \text{ and}$$

$$n0 \, \mathrm{SIN}\,(\theta) = n2 \, \mathrm{Sin}\,(\theta').$$

It is also noted that while there is usually some thin film present on any substrate, there need not be any thin film(s) present on the substrate for the described technique to be applicable. That is, the surface of a substrate per se. can be investigated through a mask (M).

Finally, it is to be understood that any mask which blocks backside reflections from entering a detector is within the scope of the disclosed invention. A mask can be made of material which is absorbing and/or scattering and/or reflecting of electromagnetic radiation, if in a direction not parallel to the electromagnetic radiation reflected from the substrate surface.

Having hereby disclosed the subject matter of the present invention, it should be obvious that many modifications, substitutions, and variations of the present invention are possible in view of the teachings. It is therefore to be understood that the invention may be practiced other than as specifically described, and should be limited in its breadth and scope only by the Claims.